Matthew Mendoza - Assignment 05 part 2

CSC 174 section 2 Spring 2023

TL;DR - All Solutions

Q1

Does this decomposition have the lossless join property?

> Yes, because the functional dependencies are preserved in the decomposition.
> We have a row that are all a's

Lossless join decomposition – avoid data corruption : No gain/no loss

Relations	C	D	E	F	W
$R_1\,(C,\ D)$	a_{11}	a_{12}	b_{13}	b_{14}	b_{15}
$R_2\,(E,\ F,\ W,\ C)$	a_{21}	a_{22}	a_{23}	a_{24}	a_{25}

Q2

> $R_3\,(A,\ D,\ W)$ is `lossless`

	A	B	C	D	E	F	W
$R_3\,(A,\ D,\ W)$	a_{31}	a_{32}	a_{33}	a_{34}	a_{35}	a_{36}	a_{37}

Q3

$$D = \{R_1\,(y,\ c,\ z,\ e,\ f,\ w),\ R_2\,(f,\ x)\}$$

Assignment 5 Part 2 - Work and steps shown

Question 1

Given $R(C, D, E, F, W)$, and the following functional dependencies:

$F\ \rightarrow\ E$

$F\ \rightarrow\ W$

$C\ \rightarrow\ D$

We decompose R into two relations $R_1(C, D)$ and $R_2(E, F, W, C)$
Does this decomposition have the lossless join property?

Question 1 - My Solution

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Relations	C	D	E	F	W
$R_1\,(C,\ D)$	a_{11}	a_{12}	b_{13}	b_{14}	b_{15}
$R_2\,(E,\ F,\ W,\ C)$	a_{21}	a_{22}	a_{23}	a_{24}	a_{25}

Question 1 - Step 1 : Set up initial a's

Relations	C	D	E	F	W
R_1	b_{11}	b_{12}	b_{13}	b_{14}	b_{15}
R_2	b_{21}	b_{22}	b_{23}	b_{24}	b_{25}

Cross-out and change corresponding relational attributes to a

$R_1\,(C,\ D)$

$R_2\,(E,\ F,\ W,\ C)$

Relations	C	D	E	F	W
$R_1\,(C,\ D)$	$\cancel{b_{11}}$ a	$\cancel{b_{12}}$ a	b_{13}	b_{14}	b_{15}
$R_2\,(E,\ F,\ W,\ C)$	$\cancel{b_{21}}$ a	b_{22}	$\cancel{b_{23}}$ a	$\cancel{b_{24}}$ a	$\cancel{b_{25}}$ a

Relations	C	D	E	F	W
$R_1\,(C,\ D)$	a_{11}	a_{12}	b_{13}	b_{14}	b_{15}
$R_2\,(E,\ F,\ W,\ C)$	a_{21}	b_{22}	a_{23}	a_{24}	a_{25}

Question 1 - Step 2 : Follow the production for each Relation (does the values match?)

$F\ \rightarrow\ E$

$F\ \rightarrow\ W$

$C\ \rightarrow\ D$

Relations	C	D	E	F	W
$R_1\,(C,\ D)$	a_{11}	a_{12}	b_{13}	b_{14}	b_{15}
$R_2\,(E,\ F,\ W,\ C)$	a_{21}	b_{22}	a_{23}	a_{24}	a_{25}

$R_1(C,\ D)$:

$F\ \rightarrow\ E : b_{14}\ ==\ b_{13}$? `True`, so no change

$F\ \rightarrow\ W : b_{14}\ ==\ b_{15}$? `True`, so no change

$C\ \rightarrow\ D : a_{11}\ ==\ a_{12}$? `True`, so no change

$R_2(E,\ F,\ W,\ C)$:

$F\ \rightarrow\ E : a_{24}\ ==\ a_{23}$? `True`, so no change

$F\ \rightarrow\ W : a_{24}\ ==\ a_{25}$? `True`, so no change

$C\ \rightarrow\ D : a_{21}\ ==\ b_{22}$? `FALSE`, so change b_{22} to a_{22}

Relations	C	D	E	F	W
$R_1(C,\ D)$	a_{11}	a_{12}	b_{13}	b_{14}	b_{15}
$R_2(E,\ F,\ W,\ C)$	a_{21}	$\cancel{b_{22}}$ a	a_{23}	a_{24}	a_{25}

Relations	C	D	E	F	W
$R_1(C,\ D)$	a_{11}	a_{12}	b_{13}	b_{14}	b_{15}
$R_2(E,\ F,\ W,\ C)$	a_{21}	a_{22}	a_{23}	a_{24}	a_{25}

Question 1 - Step 3 : Check rows

Does this decomposition have the lossless join property?

> Yes, because the functional dependencies are preserved in the decomposition.
> We have a row that are all a's

Lossless join decomposition – avoid data corruption : No gain/no loss

Relations	C	D	E	F	W
$R_1(C,\ D)$	a_{11}	a_{12}	b_{13}	b_{14}	b_{15}
$R_2(E,\ F,\ W,\ C)$	a_{21}	a_{22}	a_{23}	a_{24}	a_{25}

Question 2

Given $R(A,\ B,\ C,\ D,\ E,\ F,\ W)$ and the following functional dependencies:

$fd_1\ :\ A\ \rightarrow\ \{B,\ C\}$

$fd_2 \,:\, D \,\rightarrow\, \{E,\, F\}$

Decompose R into 3rd normal form with both dependency preservation with property and loss-less property.

Lossless join decomposition – avoid data corruption : No gain/no loss

Dependency preserving – improve performance : No joins needed to check a dependency

Question 2 - My Solution

> $R_3\,(A,\, D,\, W)$ is lossless

	A	B	C	D	E	F	W
$R_3\,(A,\, D,\, W)$	a_{31}	a_{32}	a_{33}	a_{34}	a_{35}	a_{36}	a_{37}

Approach 1

$R\,(A,\, B,\, C,\, D,\, E,\, F,\, W)$

$fd_1 \,:\, A \,\rightarrow\, \{B,\, C\}$

$fd_2 \,:\, D \,\rightarrow\, \{E,\, F\}$

$$K \;:=\; \{A,\; B,\; C,\; D,\; E,\; F,\; W\}$$

Approach 1 : Attribute A

$K - A = \{B,\, C,\, D,\, E,\, F,\, W\}$

$\{B,\, C,\, D,\, E,\, F,\, W\}^{+} = W \,\neq R$

Approach 1 : Attribute B

$K - B = \{A,\, C,\, D,\, E,\, F,\, W\}$

$\{K - B\}^{+}$		
	$= \{A,\, C,\, D,\, G,\, F,\, W\}^{+}$	Remove B
	$= \{A,\, B,\, C,\, D,\, G,\, F,\, W\} = R$ ✅	

$AC\;:\{K - C\}^{+}$		
	$= \{A,\, D,\, G,\, F,\, W\}^{+}$	Remove C

AC : $\{K - C\}^+$		
	$= \{A,\ B,\ C,\ D,\ E,\ F,\ W\} = R$ ✅	

AD : $\{K - D\}^+$	
	$= \{A,\ G,\ F,\ W\}^+$
	$= \{A,\ B,\ C,\ E,\ F,\ W\} \neq R$ ❌

AE : $\{K - E\}^+$		
	$= \{A,\ D,\ F,\ W\}^+$	Remove E
	$= \{A,\ B,\ C,\ D,\ E,\ F,\ W\} = R$ ✅	

AF : $\{K - F\}^+$		
	$= \{A,\ D,\ F,\ U\}^+$	Remove F
	$= \{A,\ B,\ C,\ D,\ E,\ F,\ U\} = R$ ✅	

AW : $\{K - W\}^+$	
	$= \{A,\ D,\ W\}^+$
	$= \{A,\ B,\ C,\ D,\ E,\ F,\ W\} \neq R$ ❌

Final Key : $\{A,\ D,\ W\}$

Approach 1 : Result

Final Key : $\{A,\ D,\ W\}$

1. Minimal cover : $E := F$
2. $R_1(A,\ B,\ C)$ $R_2(D,\ E,\ F)$
3. $R_3(A,\ D,\ W)$
4. No redundancy

Approach 2

Approach 2 - Step 1 : Initial Set-up

R is not in 3rd normal form because it's not one-to-one : $A \rightarrow \{B,\ C\}$

Armstrong Axiom : $AD \rightarrow \{BE,\ BF,\ CE,\ CF\}$

$R_1(A,\ B,\ C)$ attributes that depend on candidate key A

$R_2\,(D,\ E,\ F)$

$R_3\,(A,\ D,\ W)$

	A	B	C	D	E	F	W
$R_3\,(A,\ D,\ W)$	b_{31}	b_{32}	b_{33}	b_{34}	b_{35}	b_{36}	b_{37}

Make R_3 attributes change to a_{ij} from b_{ij}

	A	B	C	D	E	F	W
$R_3\,(A,\ D,\ W)$	$\cancel{b_{31}}$ **a**	b_{32}	b_{33}	$\cancel{b_{34}}$ **a**	b_{35}	b_{36}	$\cancel{b_{37}}$ **a**

	A	B	C	D	E	F	W
$R_3\,(A,\ D,\ W)$	a_{31}	b_{32}	b_{33}	a_{34}	b_{35}	b_{36}	a_{37}

Approach 2 - Step 2 : Follow the functional dependencies

$$fd_1\ :\ A\ \rightarrow\ \{B,\ C\}$$

- $A\ \rightarrow\ \{B\}$: $a_{31}\ ==\ b_{32}$? `False`, change b_{32} to a_{32}
- $A\ \rightarrow\ \{C\}$: $a_{31}\ ==\ b_{33}$? `False`, change b_{33} to a_{33}

	A	B	C	D	E	F	W
$R_3\,(A,\ D,\ W)$	a_{31}	$\cancel{b_{32}}$ **a**	$\cancel{b_{33}}$ **a**	a_{34}	b_{35}	b_{36}	a_{37}

$$fd_2\ :\ D\ \rightarrow\ \{E,\ F\}$$

- $D\ \rightarrow\ \{E\}$: $a_{34}\ ==\ b_{35}$? `False`, change b_{35} to a_{35}
- $D\ \rightarrow\ \{F\}$: $a_{34}\ ==\ b_{36}$? `False`, change b_{36} to a_{36}

	A	B	C	D	E	F	W
$R_3\,(A,\ D,\ w)$	a_{31}	a_{32}	a_{33}	a_{34}	$\cancel{b_{35}}$ **a**	$\cancel{b_{36}}$ **a**	a_{37}

Approach 2 - Step 3 : Check rows

> $R_3\,(A,\ D,\ W)$ is `lossless`

	A	B	C	D	E	F	W
$R_3\,(A,\ D,\ W)$	a_{31}	a_{32}	a_{33}	a_{34}	a_{35}	a_{36}	a_{37}

Question 3

Given $R\,(x,\,y,\,c,\,z,\,e,\,f,\,w)$. There are two keys: $(x,\,y)$ and z.
Given the following functional dependency:
$F = \{\{x,y\} \rightarrow \{c,\,z,\,e,\,f,\,w\},\,z\,\rightarrow\,\{x,\,y,\,c,\,e,\,f,\,w\},\,f\,\rightarrow\,x\}$.

Decompose R into `BCNF`.

Question 3 - My Solution

$R\,(x,\,y,\,c,\,z,\,e,\,f,\,w)$

Keys: $(x,\,y)$, z

$FD_1 = \{x,\,y\} \rightarrow \{c,\,z,\,e,\,f,\,w\}$

$FD_2\,=\,z\,\rightarrow\,\{x,\,y,\,c,\,e,\,f,\,w\}$

$FD_3\,=\,f\,\rightarrow\,x$

Question 3 - step 1

$D\,:=\,R$

Question 3 - step 2

$R_1 : R - \{x\} = \{y,\,c,\,z,\,e,\,f,\,w\}$

$R_2\,:\,\{f\}\,\cup\{x\} = \{f,\,x\}$

- $FD_3\,=\,f\,\rightarrow\,x$

Question 3 - Result

$$D = \{R_1\,(y,\,c,\,z,\,e,\,f,\,w),\,R_2\,(f,\,x)\}$$